Development of the Cushenbury South Quarry: Potential Environmental Impacts to Nelson's Bighorn Sheep and Suggested Mitigation

Prepared for

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September 2010

Background

Mitsubishi Cement Corporation (MCC) is proposing to develop and reclaim a new high grade quarry (the "South Quarry") at its existing Cushenbury facility. The proposed project area contains habitat that is currently utilized by bighorn sheep. For this reason, MCC has commissioned an evaluation of the South Quarry's potential to impact bighorn sheep and their habitat.

Project Description

MCC operates an existing mine and cement plant approximately 6 miles south of the community of Lucerne Valley in San Bernardino County, California. MCC is currently proposing to develop and reclaim the "South Quarry", a new high grade limestone quarry to the south of its mine and Cushenbury Cement Plant. The South Quarry will be approximately 150 acres consisting of a 128-acre quarry, a 2.7-acre landscape berm, and a 20-acre haul road 1.8 miles in length.

The South Quarry is located within portions of Sections 14, 15, 22, and 23 Township 3 North, Range 1 East. In the vicinity of the proposed South Quarry, MCC operates the East Pit (214 acres) and the West Pit (184 acres) approved by San Bernardino County in 2004 and under development). MCC's existing facilities and the proposed South Quarry are accessed directly from Highway 18 south of Lucerne Valley. The location of the existing facilities and the proposed South Quarry are depicted in Figure 1.

The project area is considered habitat for bighorn sheep. Accordingly, MCC has commissioned this report in an effort to determine whether development of the South Quarry has the potential to impact bighorn sheep, and to propose mitigation for any potential impact that is identified in the report.

General Observations On Bighorn Sheep And Mining

Mines can have either a positive or a negative influence on habitat use by bighorn sheep (Bleich et al. 2009). Activities that alter terrain and vegetation can promote occupancy of the newly altered area if they create steep (but usable) slopes, or if they reduce vegetation density or height such that they both result in improved visibility (Jansen et al. 2006). Mining activity can also deter occupancy by

bighorn sheep if human disturbance (e.g., vehicle traffic, blasting) outweighs the positive effects resulting from landscape alteration (Oehler et al. 2005). If disturbance causes animals to abandon prime habitat or influences home range size, movements resulting from disturbance could have demographic consequences, and those consequences are expected to be exacerbated for animals living in heterogeneous environments (Bleich et al. 1994), as do bighorn sheep.

Some have questioned the potential for bighorn sheep to persist in the presence of human habitation (e.g., Krausman et al. 2001), and others (King and Workman 1986) have argued that bighorn sheep continuously exposed to harassment by humans become more sensitive. In particular, some investigators have characterized bighorn sheep, particularly females accompanied by young (Wehausen 1980, King and Workman 1986), as being especially vulnerable to disturbance.

While they may be vulnerable to disturbance, female bighorn sheep, and in particular females accompanied by young, generally utilize the steepest and most topographically rugged terrain within their home ranges as a means of enhancing safety for themselves and offspring (Bleich et al. 1997). Almost by definition the areas that are utilized during the birthing season, and those months during which females are accompanied by offspring, are already removed from areas of human disturbance because of the ruggedness of the terrain. Despite this fact, however, Bristow et al. (1996) noted that female groups in mined areas showed no indication of habituation, but neither did they show increased sensitivity to human presence.

Activities associated with mining are highly predictable in a spatial sense, in that areas permitted for mining are site-specific, and generally are implemented in the same manner from day-to-day. Nevertheless, some types of disturbance, such as that associated with blasting, could affect bighorn sheep activity patterns, with a subsequent affect on quality or quantity of nutrition obtained by bighorn sheep.

Oehler et al. (2005) did not detect any relationship between the amount of ore hauled or frequency of blasting, and negative impacts on sheep at an open-pit gold mine in eastern California, and those results

are consistent with results elsewhere. Bighorn sheep in the vicinity of the open-pit gold mine studied by Oehler et al. (2005) were dependent upon a water source near that mine. Oehler et al. (2005) had hypothesized that, because bighorn sheep are physiologically dependent upon surface water during summer (Turner 1973), individuals using Redlands Spring were exposed to greater levels of disturbance than during other seasons. Nevertheless, bighorn sheep readily habituate to noise that is not threatening (Weisenberger et al. 1996, Krausman et al. 1996, 1998), bighorn sheep appear to have less sensitive hearing than do humans, and noise from mining activities is generally non-threatening and bighorn sheep readily habituate to it (Krausman 2004).

While there was no relationship between hauling and blasting and sheep responses, bighorn sheep that used a water source near the gold mine studied by Oehler et al. (2005) spent more time vigilant and, ultimately, less time foraging than bighorn sheep comprising a control group that was not exposed to mining activity. Those results were especially evident during summer, when the interval between blasting was shortest and the amount of ore hauled (an index to vehicular activity) from the mine pit was highest. Oehler et al. (2005) suggested that behavioral patterns of bighorn sheep in the mined area were the result of individuals spending more time vigilant and, as a result, spending less time foraging.

Similarly, King and Workman (1986) noted that bighorn sheep previously exposed to human disturbance foraged less efficiently when exposed to high levels of harassment. Such conclusions are consistent with bighorn sheep obtaining lower quality diets near the mined area studied by Oehler et al. (2005) when compared with bighorn sheep in control areas removed from the mine or other sources of disturbance. Those results are also consistent with the observations of others (Berger 1991, Stockwell et al. 1991, Molvar and Bowyer 1994, Bowyer et al. 2001), and were especially pronounced during summer (Oehler et al. 2005).

Despite the potential for negative influences caused by human disturbance, Geist (1971b) suggested that if harassment is adequately severe, sheep will learn to minimize encounters with humans

by reducing activity in areas, habitats, and at times of day to the point that encounters are minimized. Further, other investigators (Geist 1971a, Miller and Smith 1985, Stanger et al. 1986, Papouchis et al. 2001) have reported that bighorn sheep are quite adaptable and, if disturbances are highly predictable in temporal and spatial contexts, those ungulates readily adapt to sources of disturbance. Although there may be some period of adjustment (Hicks and Elder 1979, Miller and Smith 1985, Stanger et al. 1986, Papouchis et al. 2001), available evidence suggests that bighorn sheep are tolerant of benign and highly predictable types of disturbance (Geist 1975; Hicks and Elder 1979; Jansen et al. 2007). Indeed, numerous investigators (Graham 1980; Holl and Bleich 1983; Jaeger 1994; Divine and Douglas 1996; Oehler et al. 2005; Jansen et al. 2005, 2007, 2009) have reported bighorn sheep on or near active mines. Among other things, investigators have determined that bighorn sheep can become habituated to disturbance if such are predictable in time and space (Geist 1975, Papouchis et al. 2001), or habituation can dampen responses to disturbance (Leslie and Douglas 1980); displacement can also be temporary (Hamilton et al. 1982).

Bleich et al. (2009) also suggested that anthropogenic disturbance is of minimal concern to bighorn sheep when such disturbance is consistent in nature and occurs in highly predictable locations. Among disturbances tolerated by bighorn sheep are steady traffic on through-roads and occasional traffic on back roads, although unexpected perturbations are much more problematic (Graham 1980). Similarly, if use of the environment is confined to trails and individuals (i.e., humans) do not travel cross-country, thereby eliminating the potential for "surprising" bighorn sheep in a novel location, unexpected disturbance is less apt to occur (Papouchis et al. 2001). Even if sheep respond to the presence of humans, Hamilton et al. (1982) reported that displacement of bighorn sheep from areas upon which they have become dependent can be temporary, with sheep avoiding such areas while humans are present; presumably, if sheep become habituated to the disturbance, displacement will be less frequent or less severe.

In sum, bighorn sheep have been reported frequently on, or near, active mines (Graham 1980; Holl

and Bleich 1983; Jaeger 1994; Divine and Douglas 1996; Oehler et al. 2005; Jansen et al. 2006, 2007, 2009; Bleich et al. 2009). While some negative influences have been documented, those observations could be interpreted as evidence that mining activities can be compatible with the maintenance of populations of bighorn sheep. This is particularly true if animals are habituated to those disturbances (Geist 1975) and if disturbances associated with those activities are localized and predictable (Graham 1980). Thus, in my opinion, there will be a minimal impact of disturbance associated with mining activities to bighorn sheep as a result of the development of the South Quarry.

Existing Environment/Project Setting

The population of bighorn sheep inhabiting the vicinity of the South Quarry is estimated to be no larger than 50 individuals and currently appears to be much smaller than that (J. Villepique, California Department of Fish and Game, personal communication). Given the small number of animals comprising the population, it is predisposed to a higher probability of extirpation than would be a larger population of animals, even in the absence of perturbation.

The Cushenbury population is one of several that comprise the South Mojave Metapopulation (Torres et al. 1994, 1996; Epps et al. 2003). At a landscape level, bighorn sheep exhibit a metapopulation structure, and the metapopulation is composed of populations (often referred to as subpopulations) that have the potential for movement among them by individual animals (Schwartz et al. 1986; Bleich et al. 1990, 1996; Epps et al. 2005a, 2005b, 2007). Persistence of a metapopulation is dependent upon colonization rates that exceed extinction rates, and larger populations are more stable than are small populations (Gyllensberg et al. 1997).

Bleich et al. (2009) explored habitat utilization by bighorn sheep near several limestone mines currently operating on the west side of Cushenbury Canyon, including MCC's East and West Pits. Those authors concluded, in general, that the "area of mine disturbance" (i.e., the area within the footprint of the mines) did not appear to deter use by sheep, and further identified some of the area

immediately south of the proposed South Quarry as high-quality habitat for bighorn sheep (Figure 2).

Additional, unpublished, information depicting use by individual female bighorn sheep in the vicinity of the South Quarry provided by the California Department of Fish and Game is consistent with results reported by Bleich et al. (2009). The data indicate the north-facing slope upon which the South Quarry will be developed is used heavily by bighorn sheep. Visual inspection of the data confirms that the slopes between the existing East Pit and the proposed South Quarry received substantial use by 8 female bighorn sheep between September 2006 and March 2008. Activity isopleths generated from the aggregate locations of these sheep indicate that some of the heaviest use by bighorn sheep occurred on, or in the immediate vicinity of, the proposed South Quarry. Further visual inspection of preliminary utilization data from individual females indicated that each of them ranged widely in the vicinity of existing mine disturbance, including properties owned or operated by Omya California, Specialty Minerals, and MCC; these results are consistent with previous studies of the distribution and habitat utilization of bighorn sheep in the project area.

As a condition of San Bernardino County's 2004 approval of the West Pit, MCC was required to install three water developments for the bighorn sheep. The sheep currently utilizing the area in the vicinity of the South Quarry utilize the three water sources established by MCC, but the presence of those water sources has not been shown to be an important factor influencing annual habitat selection by those animals (Bleich et al. 2009). Bleich et al. (2009), however, did not examine the seasonal influence of water availability on habitat selection, and it could be that those water sources have influenced habitat selection only during the hot season(s).

The bighorn sheep in the vicinity of high-wall limestone mines near Cushenbury Canyon do not appear to be impacted by activities currently associated with operation of those mines (Bleich et al. 2009). However, because of its small size, the Cushenbury population is especially vulnerable to the loss of even a few individuals, a process that can have severe demographic consequences (Lande 1988). Indeed, small

populations of bighorn sheep are more prone to extinction than are those supporting more individuals because of the disproportionately greater negative influence(s) of stochastic events (e.g., drought, severe winter conditions, the appearance of a "specialist" predator, or conflagrations, etc.) on small populations when compared to larger populations. An additional factor associated with small population size can be manifested in the form of decreased genetic diversity which, ultimately, has implications for population persistence, although the demographic consequences of small population size generally can be expected to occur (as a result of stochastic events) before genetic problems arise.

Further, the degree of isolation of this population substantially decreases the probability that the area currently inhabited would be colonized by dispersing bighorn sheep. Isolation also confounds the maintenance of genetic diversity in this small group of bighorn sheep. Movements by bighorn sheep among subpopulations are critically important to genetic exchange, and provide opportunities for colonization if a population within the metapopulation was to be extirpated. Any action, for example habitat destruction or abandonment of areas as a result of anthropogenic modification of the environment, which impacts the potential for individuals to move among populations, can have long-term ramifications for metapopulation persistence.

There are three additional pressures on the population of bighorn sheep occurring near the project site that will be impacted by development of the South Quarry: parasitic infestation, harassment by dogs, and accidents. This population is infested with mites of the genus *Psoroptes* (Clark et al. 1988, Mazet et al. 1992), which further predisposes individuals to impacts associated with decreases in forage availability, magnifies the potential influences of disturbance and, ultimately, impacts body condition (Clark and Jessup 1992). Because of the small number of individuals comprising the Cushenbury population, the potential for *Psoroptes* to compromise the viability of this population must be recognized. Further, severe lesions of the external ear canal caused by mites can lead to hearing loss and, as a result, infested bighorn sheep could be more susceptible to predation (Norrix et al. 1995), either because affected

individuals are less apt to detect predators or because body condition has been compromised.

Free-ranging dogs have also previously been observed harassing bighorn sheep in the vicinity of the mine (J. T. Villepique, California Department of Fish and Game, personal communication). Bighorn sheep have been reported to respond dramatically and negatively to the presence of dogs (MacArthur et al. 1982) and other canids (Bleich 1996, 1999).

Finally, the bighorn sheep in the vicinity of the South Quarry are subject to accidents. Accidental deaths can be especially important sources of mortality when populations are small. Accidental deaths occur even in undisturbed systems (Brundidge 1987; Festa-Bianchet 1987; Kamler et al. 2003), and little can be done to minimize the probability of such natural events. Bighorn sheep also are subject to accidental deaths that occur as a result of collisions with vehicles (Cunningham et al. 1993) or becoming entangled in fences (Helvie 1971) or cables (Welsh 1971). There is at least one record of a bighorn sheep being killed during blasting activities associated with mineral extraction (J. T. Villepique, California Department of Fish and Game, personal communication).

In summary, this very small and seemingly isolated population of bighorn sheep faces great pressure even absent development of the South Quarry. Indeed, its size and isolation renders it more susceptible to the influences of habitat alteration and other perturbations associated with the South Quarry than would be experienced by a larger population. Following is a detailed discussion of how existing pressures may be exacerbated by development of the South Quarry and suggested mitigation proposed to reduce any potential impacts to the extent feasible.

Impacts and Mitigation

Issue: Direct loss of ~ 150 acres of currently used habitat

The South Quarry is expected to destroy vegetation and alter topography over an area of approximately 150 acres. The loss of habitat currently utilized by bighorn sheep for foraging will result in a decrease in nutrients available to bighorn sheep in the project area and, thereby, impact population

performance. Consequences of a decline in nutrient availability (i.e., K) include lower reproductive rates (Phillips and Alldredge 2000), lower recruitment rates (Leslie and Douglas 1982), decreased survival rates (Gaillard et al. 2000) and, ultimately, the potential for fewer bighorn sheep in the population, all of which are consistent with a decrease in ecological carrying capacity (K). Unless availability of nutrients is maintained at current levels, availability of resources to bighorn sheep on a per capita basis will be affected, and will have a concomitant impact on population performance.

Male and female bighorn sheep separate by sex for the majority of the year (Bleich et al. 1997), and the sexes use habitat differently; this differential use of habitat has potentially important implications for conservation (Bleich et al. 1997; Rubin and Bleich 2005). Although females form the reproductive base of the population, Jansen et al. (2009) reported that female bighorn sheep utilized an active copper mine but that males did not use that site during periods of sexual segregation. Jansen et al. (2009) speculated that males, because of their need for absolute greater volumes of forage, were not be able to meet their nutritional demands on the mine because of decreased availability of forage on areas that had been disturbed by mining activity.

The data also indicate the potential for a seasonal influence on the distribution of sheep, which has implications for impacts associated with development of the South Quarry. As discussed above, male and female bighorn sheep select habitat differently during parts of the year and, as a result, influences of development or disturbance can have disproportionately greater affects on one sex than the other. Despite differences in the ways that males and females use habitat, both sexes should be treated similarly when encountered by employees, and all standards for employees and mining activities should be applied equally to all animals, whether male or female.

Demographic rates of large herbivores respond to resource limitation in a predictable sequence from increased age of first reproduction, decreased survival of young, decreased reproduction by adults and, lastly in decreased survival of adults (Gaillard et al. 1998; 2000, Eberhardt 2002), all of which

impact population performance. In the absence of implementation of measures that offset a decline in K, the project area likely will not continue to support the number of animals that currently it is thought to be capable of supporting. Given the small size of this population, the consequences of loss of any currently used habitat are potentially severe, regardless of whether the losses are a direct loss of habitat to mine expansion or an indirect loss of nutrient resources because all or part of the population abandons foraging areas as a result of disturbance.

Such a loss of nutrients could be compensated for if bighorn sheep expand their distribution to take advantage of forage resources not currently utilized, but this presents trade-offs in the form of potential increases in risk of vehicle collisions or interaction with domestic sheep, as discussed below with respect to emigration (see pages 25-27). The loss of nutrients also could be compensated for if additional resources are made available by enhancing availability and quality of forage in areas currently used by these bighorn sheep. In order to offset the decline in nutrient availability anticipated to occur as the result of loss of 150 acres of currently used habitat, mitigation measures should be implemented. Mitigation may include one or more of the following measures, described in more detail below: prescribed fire, establishment of forage plots to expand foraging habitat, or improvement of existing forage habitat through irrigation and fertilization.

Prescribed fire can be used to set back vegetative succession (Bleich and Holl 1982; Holl et al. 2004; Holl and Bleich 2009), and make areas currently not utilized more attractive by decreasing visual obstructions that impact habitat utilization by bighorn sheep (Bleich et al. 1997) because such obstructions limit their ability to detect predators (Risenhoover and Bailey 1980, 1985). In the nearby San Gabriel Mountains, there was a positive relationship between habitat selection by bighorn sheep and time elapsed up to 15 years following the most recent fire in a particular area (Bleich et al. 2008). Nevertheless, Bleich et al. (2009) reported no evidence of a similar relationship among bighorn sheep in the vicinity of Cushenbury Canyon, perhaps a result of differing vegetation types. It also was possible that

sufficient time since the most recent fire in the project area had not elapsed to allow burned vegetation to advance to a seral stage having characteristics that benefit sheep; perhaps that result was a consequence of subtle differences in vegetation composition, structure, or density that were related to differences in rainfall between the north slope of the San Bernardino Mountains and the south-facing slope of the nearby San Gabriel Mountains (Bleich et al. 2009).

Another way to enhance nutrient availability and vegetation characteristics that make currently unused areas more attractive to bighorn sheep involves the planting of native or non-native forage species in areas not currently supporting those plant species and that can reasonably be expected to be used by bighorn sheep. Such methods have been successful elsewhere (Elliott, 1984; MacCallum and Geist 1992), and bighorn sheep with access to irrigated, non-native vegetation in southern California were on higher nutritional planes than bighorn sheep without access to that resource (Rubin et al. 2002). Animals utilizing non-native vegetation, however, had higher loads of internal parasites than those not utilizing that forage resource (Rubin et al. 2002).

In the absence of soil amendments or irrigation, poor soils or inadequate rainfall in the project area may preclude positive results with respect to plant productivity. Enhancements of forage quality and availability near the South Quarry and associated haul road may, however, occur as a result of water applied to control dust. Jansen et al. (2009) concluded that consistent application of water on roads, and runoff associated with compacted surfaces, could increase the predictability, quantity, and availability of vegetation at a copper mine in Arizona.

In the absence of prescribed fire or the establishment of forage plots designed to offset the loss of nutrients that occur as a result of the modification of 150 acres of habitat, irrigation (and, potentially, fertilization) of areas currently used by bighorn sheep might be used to ensure the availability of new plant growth on an annual basis, thereby offsetting somewhat the aforementioned loss of nutrients. Timing and application of water adequate to ensure maximum vegetative productivity should be

determined according to the known requirements of the principal species being treated. Of the potential mitigation measures (prescribed fire, establishment of forage plots, or irrigation and fertilization of areas currently used by bighorn sheep) noted in this section, it is my opinion that the most practical measures involve irrigation and fertilization of existing plant communities and previously developed forage plots, reclamation and re-vegetation of older un-reclaimed mine sites within the existing distribution of bighorn sheep that use the site, and planting, irrigation, and fertilization of appropriate forage species along berms, roadways, or other disturbed areas resulting from development of the South Quarry. Proposed mitigation measures are included in Table 1.

In addition to enhancing foraging habitat on-site or in the vicinity, mine design and mine reclamation should facilitate continued use of the site by bighorn sheep or re-occupation at the conclusion of mining. Bighorn sheep use habitat within mines in a manner similar to the way that habitat is utilized outside of mines (Jansen et al. 2006). Thus, Jansen et al. (2006) recommended that mining engineers work closely with biologists to ensure that resulting landscape modifications are compatible with the potential for use by bighorn sheep and that infrastructure be designed to minimize destruction of native slopes and vegetation. Further, slopes of high walls should ensure that they are accessible by bighorn sheep, and access ways associated with high walls should be designed to provide opportunities for revegetation (Bristow et al. 1996). Specific mitigation measures proposed to facilitate continued use of the site by bighorn sheep are also contained in Table 1.

Finally, some investigators (Elliott 1984, MacCallum and Geist 1992) have demonstrated that mines can provide suitable, or even excellent, bighorn sheep habitat following closure. For example, some methods can transform areas with dense vegetation and low relief to areas with open vegetation and rougher terrain and cliffs, such that occupancy by bighorn sheep is promoted (Elliott and McKendrick 1984; MacCallum 1988; Jansen et al. 2006). Moreover, mine reclamation can result in nutritional benefits to ungulates (Medcraft and Clark 1986; MacCallum and Geist 1992) that, in turn, can yield positive

population-level responses (MacCallum 1992). Development and operation of the South Quarry can be mitigated so as to minimize impacts to bighorn sheep as described in the paragraphs above. Nevertheless, following cessation of extraction activities, project proponents should implement a reclamation plan that enhances the likelihood of use of the project area by bighorn sheep.

The best way to ensure that a reclamation plan will meet that objective is for project proponents to work closely with those knowledgeable of bighorn sheep habitat requirements to meet the future needs of the affected population. Jansen et al. (2006) recommended that mining engineers and wildlife biologists work together to design reclamation plans that benefit bighorn sheep. Such plans should include designs that ensure that slopes of resulting high walls are not too steep for use by bighorn sheep, and include provisions for revegetation using forage species important to bighorn sheep. Revegetation of roadways and other disturbances associated with mining will be an integral part of reclamation, and further enhance the probability of persistence of bighorn sheep in the project area following mine closure. Additional mitigation can be achieved if habitat enhancements are applied in reclamation of the East Pit upon cessation of mining, which will occur relatively early in the life of the South Quarry project. Mitigation measures meant to ensure that reclamation is completed in a manner that minimizes potential impacts are contained in Table 1.

Issue: Dust associated with the haul road

Bighorn sheep respiratory tracts are potentially sensitive to foreign material in the form of airborne pollution, including dust; there is speculation that dust from road construction predisposed bighorn sheep to bacterial infection and was, in part, responsible for events leading to a die-off in Colorado (Jessup 1981, Bailey 1986). Given the potential for dust to be a factor predisposing bighorn sheep to respiratory distress, and potentially predisposing them to pneumonic processes, the following mitigation measures should be instituted.

Water or soil binders should be used as necessary to manage the amount of dust created by traffic

on the haul road and other access ways. Based on information provided by Jansen et al. (2009), if water is used, it should also be allocated to the berms and slopes immediately adjacent to the haul road because of the potential for additional benefits in the form of enhanced availability or quality of forage that could result in those otherwise dry areas. This action may further offset loss of forage associated with road construction and maintenance, as well as the loss of acreage currently used by sheep. Soil binders do not provide the same side benefit of increasing forage; however use of soil binders will reduce traffic on the haul road by reducing the use of water trucks. Watering,or the application of soil binder, or both, will be required to mitigate air quality impacts associated with development of the South Quarry and to comply with local Air District rules. Imposition of these measures will mitigate impacts to sheep as well. Specific mitigation meant to implement these recommendations is contained in Table 1 below.

Issue: Disturbance associated with the haul road

Development of the South Quarry includes construction of a haul road, which will pass between the East and West Pits. The haul road has the potential to be a significant source of disturbance to bighorn sheep (Figure 1).

How bighorn sheep will respond to disturbance associated with development of the South Quarry haul road remains uncertain. In order to ensure that impacts to bighorn sheep are minimized, the following effort should be undertaken. Within specified guidelines associated with logistical constraints, safety, and operation of equipment, drivers should maintain a constant speed. Stopping unexpectedly and exiting vehicles to observe wildlife should be discouraged and, to the extent practical, any stops should occur at previously specified locations. Further, foot traffic should not occur unless absolutely essential, and foot traffic that does occur should be restricted to established roads and not involve cross-country travel. Specific mitigation meant to implement these recommendations is contained in Table 1 below.

Issue: Disturbances associated with mining activity

Despite a lack of evidence demonstrating that bighorn sheep have avoided areas currently

disturbed by mining near Cushenbury Canyon (Bleich et al. 2009), increases in mining activity could affect behavior of bighorn sheep if there is a concomitant increase in blasting activity. To minimize the potential for increased levels of disturbance to affect activity patterns of bighorn sheep, it is recommended that blasting activities be standardized to the extent possible, and that they occur at the same time of day whenever such activities are carried out. Moreover, to the extent possible, minimizing the variance in the amount of blasting agent used could serve to lessen the affect on activity patterns of bighorn sheep. Additionally, minimizing changes in patterns of operation or the type of equipment used to move ore following blasting activities could reduce uncertainty associated with development of the Quarry.

If bighorn sheep are dependent on one (or more) of the water sources in the vicinity of the South Quarry and in areas susceptible to greater disturbance, and bighorn sheep abandon use of that (or those) water source(s), the development and maintenance of one or more additional water sources may be helpful in reducing affects on activity budgets of sheep using the existing water source(s). Nevertheless, there could be a tradeoff associated with such developments, in that bighorn sheep may modify their home ranges as a result, thereby further exacerbating the affects of decreased nutrient intake, or making them more prone to come into contact with livestock. Based on the results of Bleich et al. (2009), who did not explore seasonal effects of water availability, development of *additional* water sources as mitigation would not be expected to provide further benefits to bighorn sheep. A commitment, however, to ensure that existing water developments are functional and that bighorn sheep have continuing access to them is necessary. Specific mitigation measures meant to address the potential for impacts associated with mining disturbances are contained in Table 1.

Issue: Impacts to connectivity and metapopulation function

The South Quarry could decrease the potential for movements by bighorn sheep between Mt. San Gorgonio and the Cushenbury population. As discussed above, this particular population's isolation renders it vulnerable to impacts associated with a lack of genetic diversity. Accordingly, further

limitations to movement are considered a potentially significant impact that could ultimately lead to the extirpation of the Cushenbury population.

Potential mitigation for disruption of opportunities for movement by bighorn sheep occurring at Mt. San Gorgonio and the Cushenbury population could take the form of enhancing the likelihood that bighorn sheep traveling between those areas would encounter suitable habitat, and other bighorn sheep, during any such movement. Areas of suitable habitat (even if not permanently inhabited) can serve as "stepping stones" (Bleich et al. 1990) that provide opportunities for bighorn sheep to move towards or away from extant populations. In such situations, the probability of an animal that leaves one area (for example Mt. San Gorgonio) encountering suitable habitat that enhances its survival is increased, as is the probability of it eventually encountering another population of conspecifics, if it continues its dispersal movement.

A geographic area known as the Bighorn Mountains is located approximately 15 miles northwest of the area occupied by bighorn sheep at Mt. San Gorgonio, and 12 miles southeast of the area occupied by the Cushenbury population. Given some management action, habitat in the Bighorn Mountains has been identified as suitable for bighorn sheep (Crossley 1984), but opportunities for such within the Bighorn Mountains are limited because that geographic area, administered by the Bureau of Land Management, is now legislated wilderness and conservation activities proposed to occur in such areas are challenged constantly on the grounds that the 1964 Wilderness Act does not provide for such endeavors (Bleich 2005); as a result, the future of any proposal to implement mitigation in legislated wilderness would be uncertain, and likely would not occur in a timely manner. Nevertheless, if conservation actions to mitigate impacts to movements by individuals between Mt. San Gorgonio and the Cushenbury population were to be implemented in the Bighorn Mountains, the potential for the South Quarry to adversely affect the potential for gene flow or colonization of Cushenbury Canyon, should it become extirpated, would be somewhat offset.

Efforts meant to address these potential impacts could take the form of (1) water development to provide a resource that has been identified as being limited in the Bighorn Mountains; (2) modification of livestock grazing allotments to ensure adequate availability of forage for bighorn sheep, and (3) a reduction of human activities (Crossley 1984). In comments on Crossley's (1984) report, the California Department of Fish and Game (1984) noted that, "[t]he Bighorn Mountains currently are a low priority [for tanslocation of bighorn sheep], but should not be ruled out entirely if the described land use conflicts [grazing issues, off-road vehicle use, human disturbance] can be resolved." It is possible that some of those land-use conflicts (unlimited vehicular access, in particular) have been resolved by designation of much of the Bighorn Mountains as wilderness; however, as noted above, such designation creates additional problems that can confound management and conservation activities (Bleich 2005).

If such habitat modifications were undertaken, the probability of establishing or maintaining linkage between Cushenbury Canyon and Mt. San Gorgonio would be further enhanced if a "new" population of bighorn sheep was established via translocation in the Bighorn Mountains. Such an action, if successful, would provide an opportunity for genetic material contributed by animals that may immigrate to the Bighorn Mountains from Mt. San Gorgonio to eventually be transmitted to the Cushenbury population. The reverse would also occur, although the consequences of genetic isolation for animals inhabiting Mt. San Gorgonio likely are less severe than for those comprising the Cushenbury population.

In the event that the Cushenbury population became extirpated at some point in the future, the presence of a population of bighorn sheep in the Bighorn Mountains would also enhance the probability that animals emigrating from that range would recolonize Cushenbury Canyon. Thus, mitigation in the form of establishing an additional population of bighorn sheep occupying suitable habitat between Mt. San Gorgonio and Cushenbury Canyon could enhance the functionality and, potentially, persistence of the South Mojave Metapopulation. Such an approach would necessarily be dependent upon cooperation from

any land management agencies responsible for administration of the Bighorn Mountains, the full cooperation of the California Department of Fish and Game, and the availability of stock for translocation.

The types of measures that would be necessary to address impacts related to connectivity and metapopulation function would require programmatic changes in government policy and administration that are beyond the reach of a single project proponent like MCC. Moreover, the breadth of any such measures would be more than would be required to mitigate the project's impact on this herd. Accordingly, potential impacts associated with these issues would best be mitigated through contributions to a joint fund, created for the purpose of facilitating some or all of the programmatic changes that would mitigate impacts in this issue area. Ideally, the fund would be administered by MCC or another responsible body, such as an appropriate non-governmental organization, to avoid the substantial portion of the fund (~24% of the gross) that would be charged by CDFG as administrative overhead if that agency were to administer the fund. A specific mitigation measure meant to facilitate such contribution is contained in Table 1. Because the purpose of the joint fund is to address existing pressures as well as additional, unquantifiable pressures from the South Quarry Project and other future projects by other mine operators in the vicinity, the amount of MCC's contribution to the joint fund should be determined by CDFG during the environmental review process.

Issue: Impacts to population persistence

The population of bighorn sheep in the vicinity of Cushenbury Canyon is very small (Epps et al. 2003) and, as such, it is especially vulnerable to events or activities that could affect population size and, ultimately, population persistence (Lande 1988). The Cushenbury population recently has been confirmed to possess a relatively low level of genetic diversity (Epps et al. 2010).

Obviously, there is the potential for the South Quarry to impact population size of bighorn sheep inhabiting Cushenbury Canyon. Because analyses indicate the population of bighorn sheep inhabiting

Cushenbury Canyon is already low in genetic diversity, the population may be vulnerable to increased impacts associated with the development of the South Quarry. Impacts associated with low genetic diversity could be offset if additional animals were to be translocated to the area inhabited by the Cushenbury population and breeding subsequently occurred. Selection of translocation stock would be dependent upon consultation with the California Department of Fish and Game, and any proposal to augment the currently small population would require approval by that agency. In the event that a translocation were to be implemented, the logical source of animals to be moved would be the San Gorgonio population located south and east of Cushenbury Canyon, which likely was the source of the females that founded the population of bighorn sheep currently inhabiting the project site (Epps et al. 2010).

Bighorn sheep are polygynous (i.e., dominant males breed with more than one female), and some proposals have advocated translocation primarily of males to enhance genetic diversity. Nevertheless, the vulnerability of this small population to stochastic events indicates that the translocation of additional females (which would serve immediately to enhance the reproductive base of the population) would be a desirable strategy. The success of any such a translocation would, however, be contingent upon determination that adequate habitat is available to support a larger population than currently exists. If the population is determined to be at carrying capacity and development of the quarry decreases K below its current level, and there is no expansion in the distribution of bighorn sheep, no demographic benefits (e.g., increased population size) would be expected to accrue as a result of translocation. MCC's contribution to the joint fund discussed above, and described in greater detail in Table 1, would help fund any translocation deemed necessary and would mitigate impacts related to this issue area.

Issue: Loss of individuals to accidents

Development of the South Quarry will involve increased use of vehicles and use of explosives. While not currently part of the proposed project, construction of fences and erection of cables would pose

risks to bighorn sheep if they are added to project design. Thus, every effort should be made to ensure that the potential for accidental deaths associated with vehicles, fences and cables, or explosives, among bighorn sheep comprising the Cushenbury population be minimized.

To decrease the potential for accidental deaths, speed limits on the mine and the haul road should be low (≤ 15 mph) and must be strictly followed (a recommendation that probably already is in place). Further, areas on the haul road (and the mine itself) that come to be used regularly by bighorn sheep should be identified as such, and placement of signs warning equipment operators of the likelihood of encountering bighorn sheep at those locations should be considered. In addition, the 2004 Mitigation Measure BIO-12 includes the provision that, "The project proponent shall establish a training program, including new employee training and annual refreshers, to educate employees regarding bighorn sheep and the importance of avoidance" and that training program should remain in place with respect to development of the Cushenbury South Quarry.

The project design does not currently include installation of fences. However, if fences are later determined to be necessary, design specifications should preclude the possibility of bighorn sheep becoming entangled in them, yet they should not eliminate the potential for movement by bighorn sheep. Designs for fences that allow ready passage of bighorn sheep have been described in the literature (Brigham 1990; Andrew et al. 1997; Bleich et al. 2005), and have proven effective in doing so. Under no circumstances should multiple strand wire fences be used at the Quarry because of the potential for bighorn sheep to become entangled, either when attempting to jump them or when passing between the wires (Helvie 1971; Welsh 1971). Fences used to secure areas should be constructed of material in which bighorn sheep cannot become entangled (e.g., 2" chain link), and be high enough to eliminate the potential for bighorn sheep to jump them. As an additional precaution, fences should not incorporate outriggers that are fitted with razor wire or multiple strands of barbed wire unless such fences are of a height sufficient to ensure that no bighorn sheep will attempt to jump them. When constructing any fence

adjacent to a slope, the location of the substrate relative to distance from the top of the fence must be considered in fence design, and minimize the probability that a bighorn sheep would be able to successfully clear the fence if attempting to jump the fence in a downhill direction.

Although a rare event, bighorn sheep have sometimes been killed accidentally during blasting operations. Prior to the initiation of each blast in the Quarry, it is suggested that at least a cursory survey of the area in the vicinity of the planned explosion be undertaken. Detection of bighorn sheep in an area scheduled for blasting would initiate a process that would attempt to haze those animals out of the area prior to initiation of the blast. Such an action would be especially important if multiple sheep are present. Bighorn sheep are difficult to see but, in general, large groups of ungulates (like bighorn sheep) are more likely to be detected than are groups comprised of fewer individuals (Bodie et al. 1985, Bleich et al. 2001). As development of the Quarry progresses, it is likely that bighorn sheep will become acclimated to activities associated with operations if those activities occur at regular intervals and in predictable locations, and are otherwise perceived as benign (i.e., non-threatening) (Papouchis et al. 2001; Bleich et al. 2009). Thus, there is the potential for use of the Quarry by bighorn sheep to increase with time, and a concomitantly greater potential for an individual to become an accidental victim of blasting activities.

The most recent blasting accidental death in the vicinity of the South Quarry project site occurred before the 2004 approval of MCC's West Pit expansion project. The 2004 approvals required imposition of mitigation measure BIO-9. Since imposition of that mitigation measure, there have been no further accidental deaths. Given the success of mitigation measure BIO-9 contained in MCC's 2004 EIR, it is proposed to minimize the potential for accidents associated with development of the South Quarry, and is contained in Table 1, below. Additional mitigation to offset the potential for fences to result in accidental deaths of bighorn sheep also are contained in Table 1.

Issue: Abandonment of nearby birthing area

Areas used for birthing are usually located in rugged terrain that is typically beyond the range of

unpredictable human disturbance. Development of the South Quarry and, in particular, the presence of the haul road, has the potential to introduce some level of disturbance to bighorn sheep occupying the area that was identified in the 2004 EIR as a birthing area (Figure 1). However, as discussed above, bighorn sheep adapt to mining disturbances that are highly predictable in temporal and spatial contexts. Thus, while there is a potential for impacts to the birthing area, reactions of bighorn sheep to the mining activity is anticipated to be minimal, provided the recommended mitigation measures are included as part of the project.

An additional consequence of development of the haul road is the potential that it may be used by feral, or otherwise free-ranging, dogs to gain access to the mine that currently is not available to them. Bighorn sheep are especially sensitive to the presence of dogs, and react strongly to the presence of those, and other, canids (e.g., coyotes; MacArthur et al. 1982; Bleich 2006, 2009), and dogs have been known to kill bighorn sheep (Holl and Bleich 1983). Predator avoidance plays an important role in habitat selection by female bighorn sheep, and birthing and rearing areas generally are among those most apt to enhance the likelihood of mothers or their offspring detecting and evading a potential predator (Bleich 1999).

To minimize the potential for negative impacts associated with construction and use of the haul road, it is recommended that (1) the variance in the type and speed of vehicles using the haul road be minimized; (2) that the amount of traffic on the haul road be highly regulated and that it occur at regular intervals; (3) equipment operators do not stop except at locations where stops are required for safety reasons, or when equipment failure necessitates such action; (4) equipment operators or others permitted on the haul road do not approach bighorn sheep if they have reason to leave their vehicle; (5) any observations of free-ranging dogs be reported to management immediately by equipment operators; and (6) that management take immediate action to have any offending dogs removed from the mine. Specific mitigation measures meant to address these issues are contained in Table 1.

Issue: Emigration, potential for accidental deaths, and potential contact with domestic sheep

Any decrease in carrying capacity resulting from loss of foraging areas could increase the probability of bighorn sheep seeking supplemental forage. Although bighorn sheep, particularly females, are strongly philopatric (Geist 1971a), and Jansen et al. (2006, 2007, 2009) noted no affects of mining activity on activity patterns or habitat selection of female bighorn sheep, the possibility of bighorn sheep extending their ranges into currently unused areas cannot be dismissed. Indeed, Leslie and Douglas (1980) described a shift in home range use by a female sheep that may have occurred in response to construction activities.

It is possible that bighorn sheep could disperse from areas currently used, a result of either seeking greater forage resources or avoiding disturbances associated with the mine. Such dispersal likely would occur either to the east, where bighorn sheep could cross Highway 18, or to the west, where the potential to encounter domestic sheep would be increased. Bighorn sheep moving to the east would be exposed to a greater potential of vehicle collisions as a result of traffic on Highway 18 (Cunningham et al. 1993). Bighorn dispersing to the west would increase the potential for a disease epizootic to occur.

Bighorn sheep are highly susceptible to respiratory diseases, and the probability of nose-to-nose contact with domestic sheep or goats will increase substantially if bighorn sheep disperse to areas west of the Mitsubishi Mine. The consequences of contact between domestic sheep and bighorn sheep are enormous (Schommer and Woolever 2001, 2008; Wild Sheep Working Group 2007), and even a single bighorn sheep co-mingling with domestic sheep or goats ultimately could devastate the Cushenbury population (George et al. 2008; Clifford et al. 2009).

To decrease the potential for vehicle collisions to impact the population of bighorn sheep, the speed limit on Highway 18 could be lowered in the vicinity of the limestone mines, but reducing the speed limit on Highway 18 is not within the control of MCC. Alternatively, signs noting that bighorn sheep cross the road in that area (similar to deer crossing signs) could be installed to inform drivers of the potential to encounter bighorn sheep on Highway 18. Consultation and cooperation with the California Department of

Transportation would be necessary to implement either of these measures, and implementation of both would be desirable from the perspective of decreasing the risk of vehicles colliding with and killing bighorn sheep.

In order to minimize the potential for contact between bighorn sheep and domestic sheep, it is recommended that the following steps be implemented: (1) Consistent with the loss of habitat currently used for foraging, project proponents should develop forage resources through the use of prescribed fire, creation of forage plots, or irrigation and fertilization of native vegetation or existing forage plots as described previously, to replace those lost by development of the Quarry; doing so will help to offset the need for bighorn sheep to emigrate in search of alternative areas in which to forage. (2) Develop an educational campaign to advise local livestock enthusiasts of the potential for the transmission of respiratory disease from domestic sheep and goats to bighorn sheep, and the consequences thereof. (3) As part of the educational process, encourage livestock enthusiasts to immediately report to the Mitsubishi Mine staff any observation of bighorn sheep associating with domestic sheep or domestic goats. (4) Project proponents should immediately report any such observation to the California Department of Fish and Game. (5) If the bighorn sheep in question can be identified and it is determined that removal of that individual (or individuals) is in the best interest of the Cushenbury population as a whole, the project proponent should cooperate fully with the Department of Fish and Game to facilitate said removal(s). Such cooperation could involve providing access to parts of the mine for personnel or aircraft involved in any such removal effort. Mitigation measures meant to encompass the above suggestions and address impacts associated with these issues are contained in Table 1.

Issue: Infestation with *Psoroptes* mites

The proposed project will not directly impact the existing infestation of mites in the Cushenbury population. However, the project will put pressure on the population in other ways, as described previously. Overall pressure on the population can be relieved somewhat by treating the mite infestation.

If animals are captured for the purposes of monitoring responses of bighorn sheep to mine expansion, project proponents can best serve the population by (1) ensuring that resources, in the form of an appropriate parasiticide, are available to treat any animals that are captured; (2) funding a program to evaluate the responses of individual animals that are captured and treated, as well as population-level responses that might ensue; (3) funding a program to determine if mule deer, which are sympatric with bighorn sheep in the area, are infested with the same species of *Psoroptes* and if cross-transmission between deer and sheep is occurring, or has occurred; and (4) in the event that a suitable, but topical, parasiticide is developed, cooperate with the California Department of Fish and Game to provide facilities, perhaps at or near water sources, where manual applicators, or infra-red triggered applicators, that dispense the parasiticide can be deployed. These goals can be served by contribution to the fund described above and established via the specific mitigation measure described in Table 1.

Issue: Harassment by domestic dogs

Development of the haul road has the potential to facilitate ingress and egress by free-roaming or feral dogs to areas used by bighorn sheep. Females that are accompanied by young may be especially sensitive to those canids, and lambs are particularly vulnerable to predation (Bleich 1999).

In order to minimize the potential for dogs to have access to areas used by bighorn sheep, project proponents should (1) prohibit possession of pets on mine property and, if pets are for some reason on the property require that they be on a leash at all times; (2) upon determination that free-ranging dogs have accessed the mine property, take immediate action to remove the offending animal(s); (3) if immediate action cannot be implemented, notify San Bernardino County Animal Control of the problem and request that the animals be removed immediately; and (4) inform the local Department of Fish and Game contact person whenever dogs are detected on the property. A variation on mitigation measure Bio-9, discussed above, is contained in Table 1 below and will serve to reduce impacts related to harassment by domestic dogs.

Issue: Predation

Small populations of bighorn sheep are particularly vulnerable to the loss of any individuals, and even stochastic predation events can have important implications for the persistence of small populations (Festa-Bianchet et al. 2006). Although Jansen et al. (2009) and others (LSA Associates 2003) have speculated that the increased presence of humans and activities associated with mining could make mines less attractive to large predators, that argument is not compelling (Jansen 2009), and I have seen no evidence that large predators, particularly mountain lions, avoid areas high in human activity. Indeed, mountain lions hunt in and around urbanized areas, and patterns of habitat use do not seem to be deterred by the presence of humans.

All in all, predation rates on bighorn sheep would not increase as a result of development of the South Quarry. It is also unlikely that mining will result in decreased rates of predation. Accordingly, project proponents should cooperate to help ensure that predation by mountain lions does not go undetected and that any management efforts deemed by the Department of Fish and Game to be in the best interest of the population can be implemented efficaciously. To do so, project proponents should (1) immediately report any bighorn sheep mortalities, whatever the cause, to the appropriate Department of Fish and Game official, who will attempt to determine cause of death; (2) report observations of predators, particularly coyotes and mountain lions, to the appropriate Department of Fish and Game employee; and (3) in the event that losses of bighorn sheep to predation are deemed by the Department of Fish and Game to be occurring at levels that compromise the viability of this small population, cooperate fully by ensuring access to MCC properties if an individual predator has been identified for removal. A mitigation measure meant to address these recommendations is contained in Table 1, below.

Issue: Population monitoring

Without imposition of mitigation, the South Quarry has the potential to impact bighorn sheep in the vicinity of Cushenbury Canyon. Despite the measures described above and in Table 1, which are

designed to mitigate those impacts, monitoring of population size and habitat selection is necessary to ensure that mitigation measures continue to minimize impacts associated with the South Quarry. If monitoring indicates that additional measures, or measures already in place, are not meeting expectations, project proponents should incorporate into their plan the potential for "adaptive management" (Walters 1986) to be implemented.

Thus, to evaluate the responses of bighorn sheep to development of the South Quarry, project proponents should (1) Contribute to a fund that would initially capture, collar, and otherwise mark up to 30 bighorn sheep, as determined by the appropriate Department of Fish and Game biologist, in consultation with MCC and its advisor. In the event it is determined that existing data do not provide an adequate baseline, these activities should be carried out prior to the onset of South Quarry development to provide a baseline against which future population responses can be measured. (2) Contribute to a fund that would maintain a cohort of up to 30 marked individuals on an annual basis for a period determined adequate to assess the impact of the South Quarry operation on the herd and the effectiveness of mitigation; and (3) retain the ongoing services of a professional wildlife biologist that would represent MCC with respect to impacts of the South Quarry operation on bighorn sheep and review and evaluate impacts on an annual basis, collaborate with other agency personnel on the efficacy of mitigation measures, and make annual recommendations to adapt management practices to further minimize impacts. Contribution to the fund described in MM-11 contained in Table 1 would facilitate these goals and mitigate potential impacts associated with development of the South Quarry. The amount of MCC's contribution to the fund should be determined by CDFG during the environmental review process.

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Figure 1. The location of the existing facilities and the proposed Mitsubishi Cement Corporation South Quarry near Lucerne Valley, San Bernardino County, California.

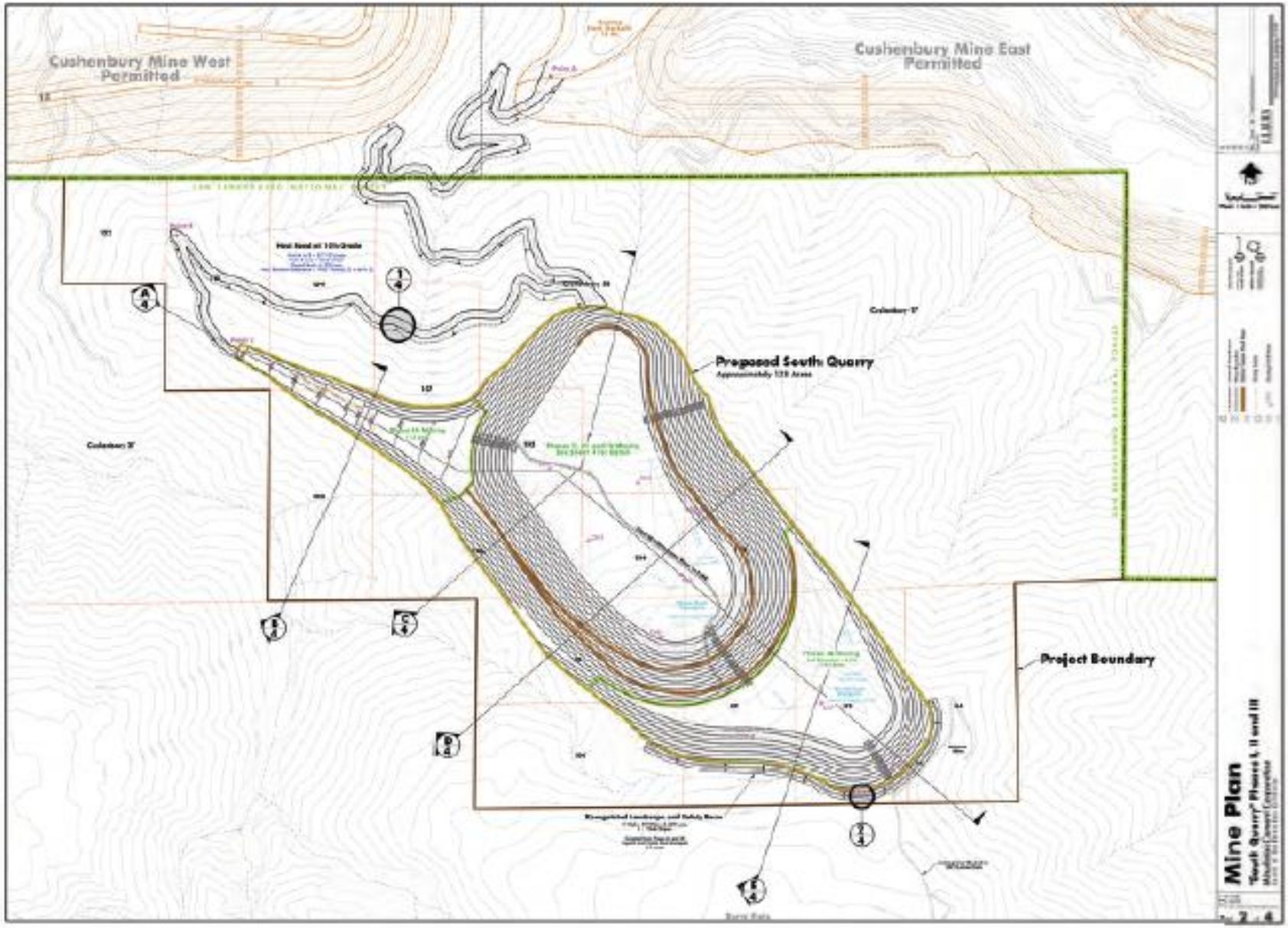
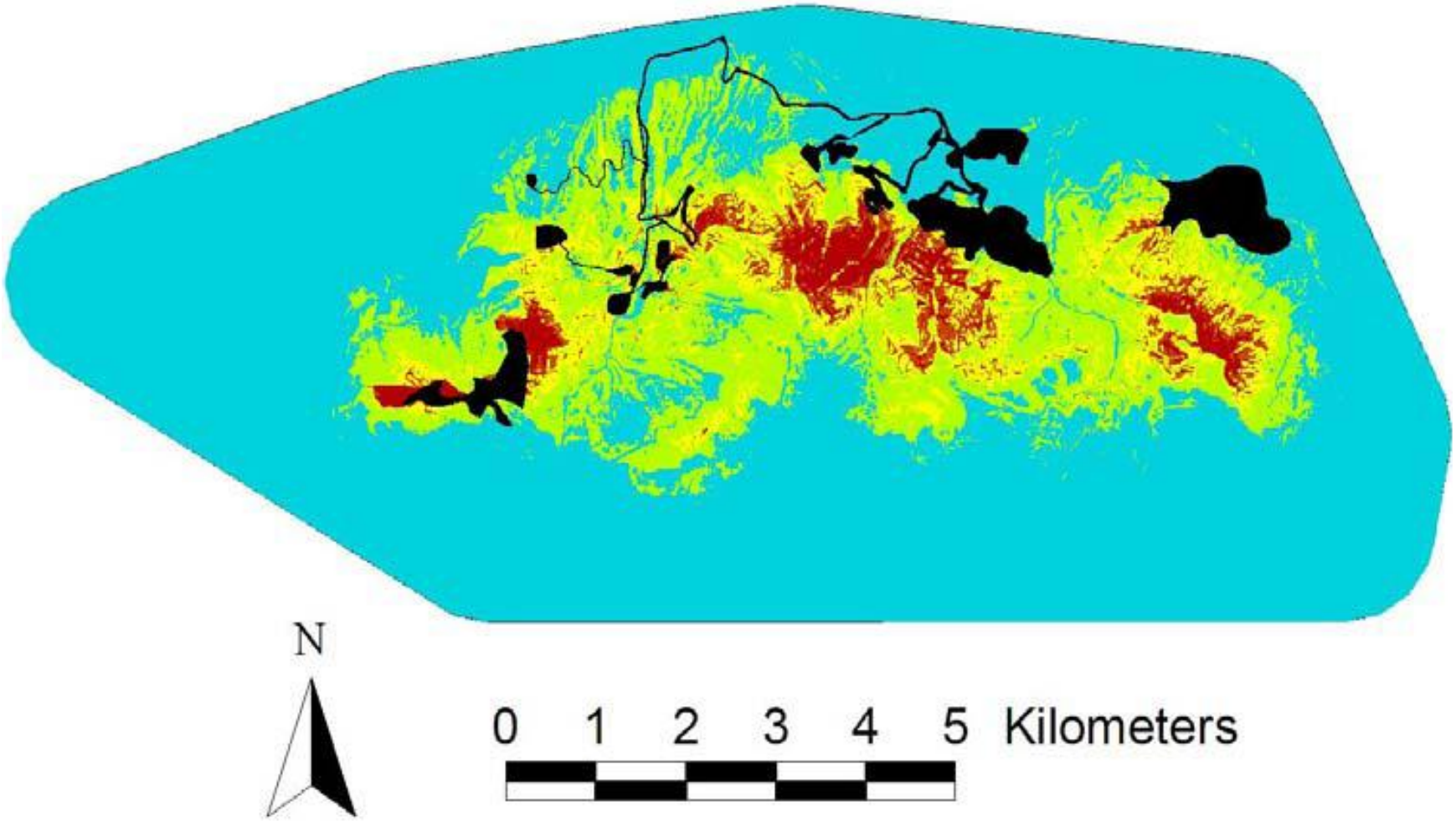


Figure 2. Predicted habitat quality based on estimated resource selection function for bighorn sheep on and adjacent to high-wall limestone mines in the San Bernardino Mountains, San Bernardino County, California (adapted from Bleich et al. 2009). Black polygons and lines represent areas modified or disturbed by mining activity, and blue represents below-average predicted sheep habitat quality. Increasingly higher-quality sheep habitat is represented by areas in yellow, green and red.



Supplement to "Development of the 'Cushenbury South Quarry': Potential Environmental Impacts to Nelson's Bighorn Sheep and Suggested Mitigation"

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September 2010

Issues and Potential for Mitigation

Issue	Potential for Success and Suggested Mitigation
Loss of ~ 150 acres of heavily used habitat	Good, depending on USFS cooperation or availability of MCC lands. Suggested mitigation:

	MM-1. In order to compensate for the loss of foraging habitat, the project proponent will enhance the forage available to the bighorn sheep. Enhancements may include, but are not limited to, irrigation and fertilization of lands near the haul road or otherwise associated with development of the project, other suitable lands in the vicinity of the project that are currently used by bighorn sheep, or reclamation of historical mining sites in the vicinity of the project, which would not otherwise be required to be reclaimed pursuant to the Surface Mining and Reclamation Act, and subsequent revegetation of such sites with forage species consumed by bighorn sheep. Prescribed fire may also be used to enhance quality and quantity of nutrients available to bighorn sheep, and will be considered in appropriate locations and in the context of existing USFS plans or constraints. CDFG must concur that the acreage chosen is appropriate for mitigation purposes, and that the enhancement plan is sufficient to compensate for the nutritional loss caused by the project. **MM-2.** Reclamation of the East Pit and the South Quarry, shall include creation of angled pathways and interlacing reclaimed benches in order to facilitate the movement of bighorn sheep and other wildlife through the pit areas. These benches will be created as the mining sequence is finished and prior to revegetation. This activity will be initiated in consultation with CDFG.
Dust associated with the haul road	Good; use on current roads does not appear to generate much dust; watering or application of soil binder will mitigate impacts. Mitigation measures requiring these efforts will be required to mitigate air quality impacts associated with development of the South Quarry or to comply with local air district regulations, and will be sufficient for purposes of mitigating this potential impact.

Disturbance associated with the haul road	Good; Suggested mitigation: **MM-3.** The project proponent shall instruct its employees and other visitors to the mine to remain in their vehicles unless safety considerations, mechanical failure, or other unforeseen circumstances dictate that they exit the vehicle. Access to undisturbed lands by humans on foot shall be restricted, and usually would include only biologists or individuals setting explosives or involved in reclamation. The project proponent shall establish a training program, including new-employee orientation and annual refreshers, to educate employees regarding bighorn sheep and the importance of avoidance.
Disturbances associated with mining activity	Good; Suggested mitigation: **MM-4.** Prior to blasting activities within the project area, mine employees shall conduct a visual inspection of the blast area to ascertain the presence or absence of bighorn sheep, deer and people. If bighorn sheep, deer, or people are located within the blast area, mine employees shall employ non-harmful measures to move the sheep, deer, or people out of the blast area prior to detonation of any blasting materials. **MM-5.** In the event that bighorn sheep abandon use of one or more water sources as a result of disturbance associated with development of the South Quarry, the project proponent shall consult with appropriate agency personnel to select location(s) for additional water development(s). The project proponent shall ensure that any existing water developments, as well as any developed as part of MM-5, are kept fully operational and maintained in good operating condition for the duration of the project.

Table 1

Impacts to metapopulation function/population persistence	Uncertain; suggested mitigation: **MM-6.** The project proponent shall establish an account in the amount of $____, which shall be used solely for the purpose of supporting joint CDFG and MCC efforts aimed at ensuring continued vitality of the herd of bighorn sheep currently resident adjacent to the South Quarry. These efforts may include, but are not limited to: (1) water development in the Bighorn Mountains; (2) modification of livestock grazing allotments; (3) establishing a new population of bighorn sheep and/or translocation; (4) ensuring an appropriate parasiticide is available to treat any animals that are captured; (5) funding a program to evaluate the responses of individual animals that are captured and treated, as well as population-level responses that might ensue; (6) funding a program to determine whether cross-transmission between mule deer and sheep is occurring; and (7) ensuring that treatment can be most effectively deployed. MCC in consultation with its expert will develop funding requests for these efforts. CDFG must approve all proposed expenditures before funds are distributed.
Loss of individuals to accidents	Good; suggested mitigation: **MM-7.** The project proponent shall provide funding for and coordinate with CalTrans to install signs warning of the potential for bighorn sheep along Highway 18 in the vicinity of the mine. **MM-8.** In the event that fencing is necessary during either construction or extraction activities, project personnel shall ensure that any such

	fences meet existing specifications that have been developed to preclude the accidental entanglement of bighorn sheep. **MM-4** above will also reduce impacts in this issue area.
Potential abandonment of nearby birthing area	Uncertain, but if vehicles and operators behave as described above, sheep could eventually be accepting of increased activity on the new haul road. The key to success is predictability of responses when sheep are encountered. **MM-1 – MM-12** described in this Table will mitigate impacts in this issue area.
Emigration and potential contact with domestic sheep	Poor; suggested mitigation: **MM-9.** The project proponent shall develop an education campaign to advise local livestock enthusiasts of the potential for the transmission of respiratory disease from domestic sheep and goats to bighorn sheep, and the consequences thereof. As part o the educational process, the project proponent shall encourage livestock enthusiasts to immediately report to MCC staff any observation of bighorn sheep associating with domestic sheep. Upon the occurrence of any observation of bighorn sheep associating

	with domestic sheep, the project proponent should immediately report any such observation to the California Department of Fish and Game. Moreover, to the extent that the bighorn sheep in question can be identified and it is determined that removal of that individual (or individuals) is in the best interest of the Cushenbury population as a whole, the project proponent must cooperate fully with the Department of Fish and Game to facilitate said removal(s). Cooperation could include but is not limited to, providing access to parts of the mine for personnel or aircraft involved in any such removal effort. **MM-10.** The project proponent shall not bring donkeys, domestic sheep, domestic goats, or feral free ranging dogs onto the proposed project site or adjacent lands under its control. The project proponent shall not authorize others to bring donkeys, domestic sheep, domestic goats, or feral free-ranging dogs onto such lands. Training for mine employees shall include instructions to report observations of domestic animals to the environmental manager. Upon receiving such reports, the environmental manager shall immediately contact the appropriate authorities for removal, and notify the appropriate California Department of Fish and Game representative that those animals were observed and action, as described above, was taken to remove them.
Issues with *Psoroptes* mites	Good, up to a point; every animal that is handled in the population can be treated with an appropriate parasiticide that has been proven effective in other populations. Research can be supported and undertaken to determine if sheep are likely to be reinfested as a result of sympatry with infested mule deer. If that is the case, it is a whole new issue. The presence of *Psoroptes* in this population makes individuals even more

	susceptible to any onerous affects associated with mining activity and resultant loss of habitat. **MM-6** above will mitigate impacts in this issue area.
Harassment by domestic dogs	Fair; **MM-10** above will mitigate impacts in this issue area.
Predation	Uncertain; suggested mitigation: **MM-11.** The project proponent shall immediately report any bighorn sheep mortalities, whatever the cause, to the appropriate Department of Fish and Game official so that the cause of death can be determined. In the event the Department of Fish and Game determines that losses of bighorn sheep to predation are deemed to be occurring at levels that compromise the viability of the population, the project proponent shall cooperate fully buy ensuring access to MCC properties to determine the predator involved, or in the event that an individual predator has been identified for removal.
Population Monitoring	Good; suggested mitigation: **MM-12.** The project proponent shall establish an account in the amount

of $____, which shall be used solely for the purpose of supporting CDFG efforts to monitor and gather data regarding the herd of bighorn sheep currently resident adjacent to the South Quarry. These efforts shall include, but are not limited to, (1) capturing collaring, and otherwise marking bighorn sheep; (2) maintaining a cohort of marked individuals on an annual basis for the life of the project; (3) funding an advisor to MCC staff to review and evaluate project impacts on an annual basis, collaborate with other personnel on the efficacy of mitigation measures, represent MCC with respect to impacts of South Quarry operation on bighorn sheep, and to make annual recommendations on adapting management practices to further minimize impacts. MCC in consultation with its expert will develop funding requests for these efforts. CDFG must approve all proposed expenditures before funds are distributed.